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KEY

TO THE

HELIOGEASTRA :

OR

COMBINED REPRESENTATION

OF THE

APPARENT and ACTUAL Relative Magnitudes, Positions and Movements in Nature, of the Sun, Earth, Stars, Constellations of the Zodiac and other parts of the Heavens, and of the Moon, Tides and Visible Planets.

A Map and Mechanism by which a child, or person of ordinary intelligence, will be able to comprehend fully, the fundamental principles of the Science of Astronomy, and to exhibit and illustrate most of its details.

Designed for Common and Universal Use, alone, or in connection with any Books which teach Astronomy.

BY

ANDREW C. LIPPITT,

NEW LONDON, CONN.

Sept. 9th, A. D. 1873.

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THE HELIOGASTRA.

CAPACITY AND CAPABILITIES OF THE INSTRUMENT.

The HELIOGASTRA exhibits, and fully illustrates, the *actual* and *apparent* relative positions and *movements* of the Sun, Moon, Stars, Earth and other Planets ; marks the Zones, or Grand Divisions of Climate on the Earth, and presents the reasons therefor.

It shows the position and Course of the Galaxy, or Milky Way, in the heavens ; what Stars, Planets, and Constellations of the Zodiac are visible on or near the Meridian, or above the Horizon, on any night, at any hour of the night, together with the name of each Constellation and principal star ; and represents the *apparent* and *actual* position, in nature, of the *Sun* in the heavens, with respect to the *Earth* in its orbit, on every day in the year.

By it may be shown or calculated sidereal time, and apparent or solar time.

By it the declination and right ascension, or in other words, the celestial latitude and longitude of the Sun, Moon, Planets, and of every star, may be shown or calculated, and the hour and minute they each will rise, cross the meridian and set throughout the year.

By it also the method of measuring the distance of the

heavenly bodies from the earth is illustrated and made clear and satisfactory to the understanding.

It represents also the sun in its *solstitial* and *equinoctial* points, and *crossing the line*, as it is called, together with the *manner* in which the phenomena of *Day* and *Night*, *Increase* and *Decrease* in the length of days and nights, *Twilight* and *Dawn*, *Heat* and *Cold*, the *Seasons*, *Full Moon* and its changes, *Harvest Moon*, *Tides*, *Transits of Venus* and *Mercury*, and *Eclipses* are produced.

The Map and Mechanism Described and Explained.

So far distant are the heavenly spheres that the eye fails to convey to the mind any correct idea of their actual positions, and hence the Sun, Moon, Stars, and Planetary Orbs, though differing in distance millions and billions of miles, all appear to be situated at the same distance from us upon the surface of a celestial dome.

In Nature, the Earth seems to occupy a fixed central position ; while the Sun and Stars, rising in the East, pass over it and set in the West. In point of fact, the Sun and Stars are fixed, while the Earth and other Planets are revolving on their axes, and moving from West to East, in orbits, around the Sun, between it and the Stars.

The HELIOGEASTRA preserves in its arrangement both the *apparent* and *actual* in Nature, and so combines and presents them that they mutually illustrate and explain each other.

The Map is an Astronomical representation or transcript of the heavens, showing the Celestial Equator, Ecliptic, Plane of the Earth's Orbit, Signs of the Zodiac, Milky Way, Constellations and principal Stars, with the

names of each. All the Stars and Constellations are placed in their true relative positions, with respect to the North Pole and with respect to each other.

The centre of the Map corresponds to the North Pole of the heavens—all lines radiating from that point are lines of Celestial longitude. They run South till they meet at the South Pole of the heavens. The outer edge of the Map corresponds to the Southern horizon. Direction from any place on the Map towards the North Pole is direction North, and direction from the North Pole towards any point on the Map is direction South.

The small circle surrounded by the Names of the Months, is in the plane of the Earth's orbit, and has the Sun for its centre.

The HELIOGEASTRA has two Suns. One called the Central or Stationary Sun, which is placed upon a pedestal in the centre of the Map. It corresponds in position to the position of the *actual* Sun in Nature. The other Sun, called the movable Sun, is placed upon the end of a slotted rod, or arm, and corresponds to the *apparent* position of the Sun in Nature.

The HELIOGEASTRA has also two Earths. One Earth, called the movable Earth, which is placed in a slotted arm, or rod, and represents as it is carried around the Central Sun, the actual Earth in its orbit. The point nearest to the Map is the North Pole, and the point to which the handle is attached is the South Pole. Its axis is at all times parallel to itself, as the axis of the Earth is in Nature. The other Earth is placed at the foot of the Map, and is made immovable, as the Earth in Nature seems to us to be. If this stationary Earth were a complete globe, revolving upon its axis, (as we can easily imagine it to be,) the rays which pass from the Movable

Sun, as it is carried North and South by the Movable *Earth* in its orbit would be cast upon it, at all times, precisely as the rays of the Sun in Nature, fall upon the Earth in Nature. The illustration would be complete in all its parts, and Day and Night, Spring, Summer, Autumn and Winter succeed each other, in all places, in their regular order.

The instrument which hangs and revolves upon the standard which supports the Central Sun is called the Indicator. The interior arm, starting from the North Pole of the heavens, is supposed to pass southerly, along the arch of the sky, through the Zenith, till it meets the horizon at a point within fifty degrees of the South Celestial Pole. The exterior arm, starting also from the North Pole, passes South in like manner, along the concave of the sky to the Horizon, and thence below, along the opposite arch of the sky through the Nadir to the South Celestial Pole.

The curved arms of the Indicator represent the horizon. They form a great circle around the Earth, whose poles are the Zenith and Nadir. Starting at the horizon, in the North, they are supposed to pass along the edge of the horizon, East and West, around the heavens.

The cross-bar is supposed to pass through the centre of the Sun, at right angles to the interior and exterior arms of the Indicator, cutting the edge of the horizon on the East and West. If allowed to assume the position which gravity will give it, the interior and exterior arms of the Indicator will mark at all times the course of the Meridian line of the heavens from the North Pole through the Zenith and Nadir, to the Southern horizon, and the curved arms the actual relative position of the horizon.

The Central Sun, therefore, in connection with the

Movable Earth, placed upon the Map among the Fixed Stars, and revolving upon its axis as it moves in its orbit, represent the *Actual* in Nature ; the stationary revolving Earth, Movable Sun, Indicator, and Revolving Map. the *Apparent*, and all, together, the actual and apparent combined.

The great Circle, having the North Pole on the Map for its centre, is the Celestial Equator, or line which the plane of the Earth's Equator would describe if extended to the heavens. Distance from that line to points *within* the circle, is called Declination North ; and distance from the line to points *without* the circle is called Declination South. All circles which can be drawn upon the Map parallel thereto are parallels of latitude.

The figures placed along the inner side of the Equatorial line, mark, in degrees, Right Ascension, beginning at the sign Aries. If any point upon the circle be selected, all the other points situated upon the same line, in a direction corresponding to the order of the names of the months, will be in a direction due East from it ; and all points situated in the opposite direction, will be in a direction due West of it. Every point, within or without the circle, is in a direction either North, South, North Easterly, South Easterly, North Westerly or South Westerly from the point selected. The same will be true in respect to course or direction from points selected, in any circle which can be drawn on the Map, having the North Pole for its centre. Andromeda is therefore East of Pegasus ; the Lynx is East of Auriga ; Bootes is East of Ursa Major, and the Lyre East of Hercules.

Starting from 0, at the Equator of the heavens, the edge of the interior and exterior arms of the Indicator is marked, or spaced off in figures, within and without the

Equatorial Circle, to mark or measure Declination. Distance outside of the Celestial Equator is Declination South, and distance inside the Circle is Declination North or latitude North.

The remaining great circle is called the Ecliptic. It shows the apparent path of the Sun in the heavens, and its apparent position at all times; for the Sun seems to move continually from West to East, through the Signs and Constellations of the Zodiac, as the Earth moves in its orbit. From the Vernal Equinox to the Summer Solstice, the line extends within the Equatorial circle, or North, as the Sun advances in the heavens; from that point it approaches that circle, in its course, and crosses it at the Autumnal Equinox. The Sun is then said to cross the line. From thence the line proceeds without the circle, or South, as the Sun seems to move in the heavens to the Winter Solstice, whence it returns again and crosses the Equatorial circle at the Vernal Equinox, when the Sun is again said to cross the line.

The figures upon the inner side of the circle mark degrees between the Signs of the Zodiac, and the dots and figures upon the outer side, the days of the months: for the Sun's apparent position always coincides with the point given for the day of the month.

General Remarks, and Rules to be Observed in the Use of the Instrument.

With respect to the Stationary Earth, the observer is supposed to be standing in front, and looking East across it, with the North Pole at his left hand and the South Pole at his right; and with respect to the Map, Zodiac,

Stars, Earth and other Planets in their orbits, he is supposed to be standing with his back towards the South Pole, and his face towards the North Pole of the heavens. It is obvious that as the Earth moves to the right and revolves to the right, to a person standing upon the Movable Earth, with his face towards the lower or North Pole, the right hand will always be East, and the left hand West.

To get a clear and correct conception of the relative positions of the Sun, Earth, and Stars in the HELIOGE-ASTRA, a person must conceive of them as situated within, and upon, the interior surface of an immense hollow globe; that a portion of the Southern Pole, or end of the globe 50° in length has been removed, and that he has entered through the opening into the interior, and, while standing upon the Movable Earth, he is observing the movements. The Sun is seen to occupy a fixed central position, half way between the North and South Poles. The exterior Planets and Constellations of the Zodiac occupy their proper places on the surface of the Globe upon and near the Celestial Equator, and the other Stars and Constellations are spread out upon and cover the whole interior surface of the Globe. While the Globe with its little firmament of Stars remains fixed and immovable, the revolving Earth upon which the observer stands, moving in its orbit between the Sun and the Stars, brings into view and to the Meridian, in succession, each and every Constellation of the Zodiac and of the heavens.

The graduated arms of the Indicator, starting from the North Pole as a central point, would be seen passing along through the Zenith above and the Nadir below, on the surface of the Globe to the opening, marking the

Meridian line. The curved arms would in like manner be seen to pass from about 50° below the North Pole, along the interior surface upon opposite sides of the Globe, to the edge of the opening, marking the line of the horizon.

Place the Movable Earth upon the name of any month in the year; hold up the HELIOGEASTRA before you with the back towards the North Pole of the heavens, in such manner that the right arm of the Indicator shall be upon the name of the month, and the edge of the left arm upon the dot or figure on the Ecliptic, which stands for the day of the month, and the point where the right arm crosses the small circle, will then be the true relative position of the Earth in its orbit on that day; that part of the Map which is embraced within the circle, or curved arms of the Indicator, will exhibit a transcript of the heavens, visible in the Northern hemisphere at the hour of six o'clock in the afternoon of that day, and every Constellation and important Star visible in the heavens, will be found to occupy a corresponding place upon the Map, with its name attached.

Revolve the top of the HELIOGEASTRA from right to left, at the rate of fifteen degrees for every hour, and one degree for every four minutes, and the Map, with its Stars and Constellations rising in the East, passing the Meridian and setting in the West, will continue to represent in like manner, the visible heavens throughout the night.

The latitude of any observer on the *Earth*, and his Zenith point upon the Sky, Indicator and *Map*, coincide.

If a circle be struck upon the Map, passing through the point corresponding to the latitude of any observer, having the North Pole for its centre, all Stars represented on the Map, situated within the circle, will pass the

Meridian North of such observer's Zenith point in the heavens, and all stars situated without the circle, will pass the Meridian South of the observer's Zenith point; and *vice versa*, all the Stars in the firmament which pass the Meridian any number of degrees, North of the Zenith point of an observer, will be found situated upon the Map the same number of degrees within the circle, and all Stars which pass the Meridian South of the Zenith point of the observer, will be found upon the Map the same number of degrees outside of the circle.

THE PLANETS.

The Exterior Planets, or those situated without the orbit of the Earth, are placed among the Stars, where they appear to us to be. The interior Planets, or those situated within the orbit of the Earth, are placed on arbors, at their respective relative distances from the Earth and Sun. The exterior Planets may be taken up and moved along to correspond with their actual movements from Constellation to Constellation in the heavens.

NEPTUNE is a purely telescopic Planet.

URANUS is rarely visible, except through a telescope.

SATURN is visible to the naked eye as a Star of the third magnitude, of a pale blueish tint. Provision is made for placing it and preserving a record of its progress from Constellation to Constellation around the heavens.

JUPITER appears to the naked eye as a Star of the first magnitude, of a pale yellow color. Ample provision is made for preserving a record of its progress among the Constellations.

The ASTEROIDS, situated between Mars and Jupiter, are invisible to the naked eye.

MARS appears like a Star of the second magnitude, and of a reddish hue. It can be moved from Constellation to Constellation, as the Planet moves.

VENUS is the most conspicuous, and to the naked eye, the largest and most brilliant of all the Planets. It is always seen in the direction of, and near the Sun, and is exceeding bright and beautiful. Its color is silvery white. It is placed on an arbor attached to the Sun.

MERCURY, from its nearness to the Sun, is seldom seen. It appears as a star of the third magnitude, and of a pale rosy color. It is placed on an arbor next to the Sun.

The exact position, or right ascension of Mars, or of any other of the Planets in the Constellations, may be determined, at any time, by referring to the Almanac, and multiplying the hours of rising, crossing the Meridian, or setting, there found, by fifteen, and adding one fourth of the minutes to the product. The result will be the right ascension of the Planets in degrees on the Equator at that time.

Declination and Right Ascension of the Stars and Constellations, and their Times of Crossing the Meridian.

The Stars and Constellations of the Zodiac, and other Constellations which cross the Meridian, after six o'clock during any given night in the year, will be those situated on the HELIOGEASTRA within a distance of 90° on either side of the point where the right hand arm of the Indicator crosses the Celestial Equator, at that hour, on the day named. And, as the Earth is constantly revolving on its axis from West to East, while the Stars remain stationary, the Constellations will rise, appear on the

Meridian, and set in succession ; those placed at a distance of 45° West of the point, will be over-head at nine o'clock in the evening, those situated immediately above the point named, at midnight, and those situated at a distance of 45° East of the point, will be over-head at three o'clock in the morning.

Place the graduated edge of the interior arm of the Indicator at the centre of any Star, and the number of degrees represented on the Equatorial line, at the place where it is crossed, shows its right ascension ; the distance in degrees at which it is situated outside or inside of that line, shows its declination, or latitude North or South. The place where it crosses the small circle, shows the month ; and the place where the exterior arm crosses the Ecliptic shows the day of the month on which the Star will cross the Meridian. And, if you divide the number of degrees shown at the point where the interior arm crosses the Equatorial line, by fifteen for the hours, and multiply the remainder, if there be any, by four, for the minutes, the result will show what hour and minute of the twenty-four, Sidereal time, the Star will cross the Meridian.

How Heat and Cold, Spring, Summer, Autumn and Winter are produced. Winter and Summer Solstice.

The Sun is said to be vertical, over any point on the Earth, when a line, drawn from the centre of the Sun to the centre of the Earth, would pass through it.

The various parts of the Earth are warmest when the Sun is nearest vertical over them, and coldest when the rays of the Sun fall most obliquely upon them.

It is therefore the change in direction in which the rays of the Sun fall upon the Earth, and not a change of the distance of the Sun from the Earth, (for it is nearer by about three millions of miles in January than in July,) which produces the changes of heat and cold, and, consequently, Spring, Summer, Autumn, and Winter, on the Earth. These changes in the direction of the rays of the Sun, are caused by the change in the relative positions of the poles of the Earth with respect to the Sun as it moves in its orbit. They will be made strikingly apparent to the observer by placing the Earth in the Equinoctial, and then in the Solsticial points, and noting the change in the direction of the rays, from the movable Sun, as they fall upon the stationary Earth. For six months in the year the South Pole is illuminated and the North Pole in darkness, and for the remaining six months the North Pole is illuminated and the South Pole in darkness. A person standing at the Equator of the stationary Earth, on the 20th day of March and 23d day of September, would see the Sun directly over his head; from March to June, farther and farther to the Northward, and from September to December, farther and farther to the Southward of him, on each succeeding day. Precisely the same changes, in the direction of the Sun's rays, would be observed by a person standing on the Equator of the movable Earth in its orbit. It is evident, therefore, that the *apparent* changes, in the position of the Sun, in Nature, are not owing to any *actual* change, as it seems to us to be, but wholly to a change of the *direction* in which its rays come to us, by reason of the change of the position of the Earth, while its axis remains unchanged.

As the Earth is moved around the central Sun of the HELIOGEASTRA, the position of the movable Sun, with

respect to the stationary Earth, shows the true *apparent* position of the Sun in the heavens, in Nature, at all times and places, and not only that, but the direction in which the rays from the movable Sun fall upon the stationary Earth, exhibits to the eye a *record* of the *manner* in which the *rays* of the Sun, *in Nature*, are falling upon the Earth *in Nature*, the changing seasons, as they actually exist, in all parts of the Earth, on every day in the year.

Spring actually commences, in the Northern Hemisphere, when the Sun crosses the Equinoctial line, on the 20th day of March, and in the Southern Hemisphere, when the Sun crosses the Equinoctial line, on the 23d day of September.

For a number of days, prior and subsequent to the 23d day of December and the 21st day of June, in each year, when the Earth reaches those points in its orbit, the apparent change of the position of the Sun is so very slight, as is shown by the movable Sun in the HELICGEASTRA, that it is said to stand still. For that reason those points are called the Winter and Summer Solstice. They mark the time when Winter and Summer respectively begin.

ZONES AND CLIMATES.

It will be seen, as the Earth is moved around the central Sun, that the movable Sun remains vertical, or nearly vertical, over all parts of the stationary Earth situated between the lines marked as the Tropic of Cancer and Tropic of Capricorn; that it is never vertical North or South of those points; hence, that part of the Earth, because of the extreme heat which prevails, is called the

Torrid Zone, and the climate Tropical, because it lies between the Tropic lines.

Within the Arctic and Antarctic circles, the rays of the Sun fall very obliquely upon the Earth. At the poles, for six months in the year, and, as far down as the Arctic and Antarctic circles, on the 23d day of December and 21st day of June, alternately, they do not touch it at all. For this reason, the climate is intensely cold, and the regions themselves are called Frigid Zones.

North and South of the Equator, between the Polar circles and the Tropic lines, as the rays of the Sun are never vertical, as in the Torrid Zone, and never fall so obliquely as within the Polar Circles, the extremes of heat and cold, peculiar to those regions, never prevail, and the climate is called Temperate, and the regions themselves Temperate Zones.

Day and Night, Twilight and Dawn, and Times of Rising and Setting of the Stars.

The rising and setting of the Sun divides the hours into day and night. The phenomenon, called the rising and setting of the Sun and Stars, is caused by the revolution of the Earth on its axis. At the same instant of time, it is noon to the people residing on the side of the Earth next to the Sun. Midnight to those living at the opposite point, Sunrise to those coming around to the point where they can just see the rays of the Sun, and Sundown to those just passing out of the rays of the Sun into the shades of evening, or shadow of the Earth.

The Earth moves in an Elliptical Orbit, and is about three millions of miles nearer the Sun on the first day of

January, than it is on the third day of July. Its velocity is accelerated or retarded by the attraction of the Sun as it advances towards or recedes from the point in its orbit nearest the Sun.

When the Sun is on the Equator, or crossing the Equinoctial line, as it is called, it rises and sets at six o'clock, and the days and nights are, consequently, of equal length, in all parts of the globe.

To the people in the Northern hemisphere, the Southern horizon, with respect to the Sun, from the 20th day of March to the 23d day of September seems to be depressed, causing the Sun to appear earlier, and remain longer, than six o'clock, above the horizon; and from the 23d day of September to the 20th day of March to rise again, causing the Sun to appear later above, and to sink earlier beneath the horizon than six o'clock.

This is owing entirely, as before explained, to the change of the relative position of the axis of the Earth, with respect to the Sun, as it moves in its orbit.

Place the Moon at its full, or change, when the Earth is at one of the Equinoxes, and then move the Earth around its orbit, revolving it as it moves, while the Moon is held in the same position, and the plane which the Moon describes as it moves, with respect to the Sun, six months below and six months above it, will beautifully illustrate the apparent rolling, or dipping and rising of the line of the horizon, at different periods of the year. The Sun is longest above the horizon, and the days longest at any place, when the Sun apparently rises highest above the horizon, or towards the Meridian, at noon. The days and nights increase or diminish in length, relatively, North or South of the Equator, as the vertical rays of the Sun advance towards, or recede from

the Tropic lines. It is this change in the rate of the Earth's motion, in connection with the relative change of its axis, with respect to the Sun, which causes the difference in the length of days and nights on the Earth.

Bring the curved edge of the right, or Eastern, arm of the Indicator, to the centre of a rising Star, or the curved edge of the left, or Western, arm of the Indicator, to the centre of a setting Star; ascertain, in each case, the number of degrees and parts of a degree there are on the Ecliptic, between the point for the day named, and the point where the curved edge of the Indicator crosses the Ecliptic; divide the number of degrees and parts of a degree thus found, by fifteen for the hours, and multiply the remainder, if there be any, by four, for the minutes; add the product to six hours, if after, and subtract it from six hours, if before six o'clock, and the result will be the time the Star will rise or set, as the case may be.

TWILIGHT begins, morning and evening, at any place when, and continues as long as, the rays of the Sun, from the West or East, passing across the Earth, strike the particles of matter in our atmosphere, at such angles as to throw their light to the Earth.

Twilight begins earliest, and lasts longest, in those parts of the Earth, where the rays of the Sun fall most obliquely.

Declination of the Sun. Sidereal Time, Solar Time, and Mean Solar or Clock Time.

The declination of the Sun, is its distance, in degrees, inside or outside the circle of the Celestial Equator. Sidereal time is time measured from one transit to another of a Star across the Meridian.

Solar time is time measured from the time the Sun crosses the Meridian of any particular place, till it shall cross it again. Add three minutes and fifty-six (3 m. 56 sec.) seconds to sidereal time, and the product will be solar time. Mean solar, or clock time, is the average of all the solar days. By it the days are made to consist of twenty-four hours each. The Sun is sometimes faster and sometimes slower than the clock. On the 15th of April, 15th of June, 1st of September, and 23d of December, they agree.

The time when the Sun, or any Planet or Star, will rise, cross the Meridian or set, having been ascertained, from an almanac calculated for any particular Meridian, all that is necessary to do, to accommodate it to your place of observation, is to add or subtract the difference in longitude, between that place and your place of observation, one hour for every fifteen degrees, and four minutes for each additional degree of longitude.

The Moon and its Changes. Harvest Moon.

The Moon revolves around the Earth in $29\frac{1}{2}$ of our days, and revolves but once on its axis during its revolution around the Earth. The effect is the same, with respect to the Earth, as it would be, if it were placed upon the end of a spindle, as it is exhibited in the HELIOGEASTRA. The same side is always turned towards the Earth.

It is New Moon when it comes into a position nearest the Sun; in Quadrature, or is said to quarter, when, with the Earth and Sun, it forms a right angle; and Full Moon, when it reaches a point, on the side of the Earth

farthest from the Sun. New Moon appears smallest, and Full Moon largest, when the Earth, Moon and Sun are nearest to being on the same line.

It rises farthest South, when the Sun seems to rise farthest North, and farthest North when the Sun seems to rise furthest South. This phenomenon of Nature and the reason for it, will be obvious to any one, who will carefully inspect the working of the *HELIOGEASTRA*.

On the 20th day of September, the Horizon and Ecliptic are nearly parallel. If, at that time the Moon shall be at its full, and rise at six o'clock on the Ecliptic, it will, by reason of its position, rise later by less than thirty minates, on each successive night, for several nights. The days for labor in the gathering in of the harvest, are thereby prolonged, and the Moon is called the *HARVEST MOON*.

TIDES.

Tides on the Earth, are the effect of the Moon and Sun's attraction, drawing the waters and atmosphere of the Earth towards themselves. The attraction is greatest, and the highest, or Spring tides formed, when the Sun, Moon and Earth are all in the same line and act together; and least, and Neap tides formed, when they are so situated as to act at right angles, and thus in part neutralize the effects of each other.

TIDES are formed, at the same time, on opposite sides of the Earth, under and opposite the Moon, and move around from East to West, in manner shown in the *HELIOGEASTRA*, as the Earth revolves. When it is high tide at any two points, on opposite sides of the globe, it is low water, on opposite sides of the Earth, just half way between them.

TRANSITS AND ECLIPSES.

An Eclipse of the Sun occurs when the Moon in its orbit, passes between the Earth and Sun in such manner as to intercept a portion of its rays. It is visible, only, to those people living on the line of intercepted rays. It is partial to those within the penumbra, and total to those within the umbra.

An Eclipse of the Moon takes place when the Earth passes between it and the Sun, so as to intercept the rays of the Sun on their way to the Moon.

Eclipses of the Sun always occur at New Moon, and Eclipses of the Moon always at Full Moon.

As the Moon revolves around the Earth in a different plane from that of the Earth around the Sun, Eclipses cannot occur except when the Moon is near its Nodes, or plane of the Earth's orbit; that is to say, within 17° at the time of her change, or within 12° at the time of her full.

There can never be less than two Eclipses in a year. There may be seven in all: five Solar and two Lunar. The most usual number is four. When there are but two, both will be of the Sun.

A Transit is said to occur when a heavenly body crosses, at the same time, the disk of the Sun and the Meridian of any place. A Planet will pass, or seem to pass over the disk of the Sun, when it passes on a line between our Planet and the Sun. This can never happen, except when the Planet is near the Ecliptic, or its Nodes. The Transits of Venus occur only in December and June, and of Mercury only in May and November.

Methods of Measuring the Distances of the Heavenly Bodies from the Earth.

There is a rule, in Mathematics, by which, if one of three sides of a triangle, A. B., and the angles A. B. C. and B. A. C., which the two adjacent sides make with it, are known, the length of the remaining sides, or of a line drawn at right angles from the side whose length is given, to the point of the remaining angle (C. D.), can be readily determined.



This rule is familiar to Surveyors, and is constantly applied by them, in making survey of lands, when they wish to ascertain the distance across a lake or river, or to any object which is inaccessible.

Place the movable Sun, in the HELIOGEASTRA, on the line of the Equinoxes, and the lines or rays passing from it to the poles of the stationary Earth, in connection with the axis of the stationary Earth, will form such a triangle.

The length of the axis of the stationary Earth, in the HELIOGEASTRA, and the length of the axis of the Earth, in Nature, both being known, if the angles are also known, which the lines, drawn from the poles of the stationary Earth to the movable Sun, make with the axis of the stationary Earth, in the one case, and the angles which the lines of sight, from the poles of the Earth, to the Sun, in Nature, make, with the axis of the Earth, in Nature, in the other, it is obvious, that, by applying the rule with respect to triangles, above referred to, the distance from the stationary Earth to the movable Sun, in

the HELIOGEASTRA, or, from the Earth, in Nature, to the Sun, in Nature, could be easily ascertained.

The same results would be reached if any two points on the Earth, and the distance between those points, as, for instance, between Cape Horn and the City of Boston, or Greenwich and the Cape of Good Hope, were taken as a basis for this calculation.

Should such a test be applied to the Sun and Moon, it would be found that the Sun is about 95,000,000, and the Moon about 240,000 miles from the Earth.

Since, therefore, such is the distance of the Sun from the Earth, if there are any persons who still hesitate to believe the statements of Astronomers, deeming the conclusions of Science incredible, that the Earth revolves upon its axis, at the rate of 1000 miles per hour, thereby producing the changes of day and night every twenty-four hours, and that it moves sufficiently rapid through space to perform the circuit of its journey, around the Sun, a distance of about 570,000,000 of miles, in a period of *one year*, thereby producing the changes of Spring, Summer, Autumn and Winter, they must take the other alternative and believe that the Sun, a body 1,400,000 times larger than our Earth, large enough to appear of the size it does, at a distance from us of 95,000,000 of miles, revolves around the Earth, performing the same journey, of about 570,000,000 of miles, in a period of *twenty-four hours*, and thereby produces the changes of day and night—and not only so, but that it swings, from its extreme point of rising South in December, to the extreme point of rising North in July, over a space of 47° of the Eastern horizon, about 75,000,000 of miles, and back again to the same point in December, thereby producing the change of Seasons.

The conclusions of science are wonderful, but the other alternative surpasses belief.

By inspection of the HELIOGEASTRA, we shall see that the Earth's position, in January and July, is on opposite sides of the Sun. The distance across its orbit is twice the distance from the Earth to the Sun, or about 190,000,000 of miles. It is obvious, therefore, that if lines were drawn from the termini of a line across the Earth's orbit, to any Star on the Map, they would form with that line another triangle.

Now, if a person on the first day of January, and again on the third day of July, by means of an instrument, used for the purpose of measuring angles, should look at a distant Star, and thus ascertain the angles which these two lines of sight make with the line across the orbit of the Earth, we should expect that, by applying the rule referred to, he would be able to measure the distance of the Star from the Earth. Such would be the fact, if the Star were not more distant than (20,000,000,000) twenty billions of miles. But when we apply the test to a fixed Star, the distance across the orbit of the Earth is so short, in comparison with the distance to the Star, that the lines of sight form no angle with it, and approach so near to parallel lines, that the difference cannot be appreciated by any instrument which has yet been constructed. Hence, the actual distance to the Stars cannot be measured. It is known, however, that the nearest of them is distant more than twenty billions of miles, but how far beyond, in the far off space, it is impossible for man, with his present knowledge of Astronomy, to tell.

THE SUN.

IN the HELIOGEASTRA the Sun is represented as immovable, in a central position. Such, however, is not its actual condition, in Nature. It is revolving around some distant central orb, as the Earth moves around it. Professor Madler, a distinguished Astronomer, of Dorpat, in Russia, has announced, that Alecyone, one of the Pleiades, or Seven Stars, as they are called, is that Central Orb. It is so far distant as to appear to us but a mere speck of light in the firmament. Astronomers also tell us that the Sun is a body about 1,400,000 times larger than our Earth; that the Planets were once a part of its substance, and have been thrown off from its surface, at different periods of its history; that it is now moving through space, in the direction of the Constellation Hercules, and will continue to move off in space, in the same general direction, at the rate of about 38,000 miles the hour, for a period of 9,100,000 years, its period being 18,200,000 of our years; and that, so immense is the circle of its orbit, that it has passed over but about 1-3000 part of its orbit since Man was placed upon the Earth. Has it ever been around its Central Orb? How many times? Has it passed its perihelion as many times as there are Planets in our System, casting off one at every revolution? How immense must be the circuit of the Sun! How vast the ACTUAL MAGNITUDE of its Central Orb, whether it be Alecyone or any other fixed Star in the heavens, visible or invisible to the naked eye, since it is certain that it is LARGE ENOUGH to curb the fiery Sun in its course, with all its retinue of Planets, and *determine its orbit*, at such

vast distance, by the mere power of attraction! Science fails to compass, the imagination is lost in the contemplation of Magnitude, Time, Distance and Space, so immense, and the problems must be left for future minds to solve.

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